Fractionation of Foreign Matter in Ginned Lint Before and After Lint Cleaning

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Abstract. *One goal of lint cleaning at a cotton gin is to reduce the non-lint material to an acceptable level with minimal fiber damage. In an effort to improve lint cleaner performance, an initial study was conducted on lint collected before and after lint cleaning at nine commercial gins across the cotton belt to characterize non-lint content. Samples from this study were first processed with an MDTA-3 (Micro Dust and Trash Analyzer 3, SDL Atlas, Stockport, U.K.) to determine trash, fiber fragment, and dust content. The trash portion was retained for additional manual fractionation to determine the percent of material classified as seed coat fragments (SCF), motes, funiculi, sticks, leaf, bark, lint, and "other" material. Leaf, SCF, and sticks were the largest fractions, accounting for 81% of the total trash sample. Overall, total trash decreased by 57% due to lint cleaning, and trash fractions remained consistent in samples before and after lint cleaning. Lint cleaning efficiency in terms of SCF was less than the overall cleaning efficiency, and lint cleaning efficiency for bark, mote, and other (all minor components) was higher than the overall cleaning efficiency. The lint cleaning efficiency for SCF was increased significantly when higher SCF levels were found before the lint cleaner, but this trend was not found for other fractions. Results of this experiment will help direct future studies to improve lint cleaning.*

Keywords. *Cleaner, Cleaning, Cotton, Fractionation, Funiculi, Leaf, Lint, MDTA-3, Mote, Seed coat fragment, Stick, Trash.*

Saw-type lint cleaners remove trash from cotton lint before packaging. These cleaners are very efficient in reducing the total amount of trash, but they are aggressive, causing fiber breakage and entanglements (Anthony 1990). A lint cleaning survey of commercial cotton gins across the cotton belt was conducted in an effort to improve the performance of lint cleaners by minimizing fiber damage while improving cleaning efficiency (Whitelock et al., 2007). One goal of the survey was to quantify and characterize different types of foreign matter found in lint before and after lint cleaning.

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The standard method for determining the non-lint content in cotton utilizes the Shirley Analyzer (ASTM 2004). In this method, foreign matter is mechanically separated from lint and reported by weight as visible waste content. This foreign material consists of dust, sand, seed coat fragments (SCF), leaves, stems, and other material typically found in processed cotton.

Morey et al. (1976) evaluated the Shirley Analyzer visible waste separated from lint obtained before and after one lint cleaner. The lint cleaner reduced the visible waste content from 67.2 to 33.5 mg/g lint. The waste was fractionated by size and categorized with a microscope as leaf, stem, boll, seed (mostly seed coat fragments), non-cotton, and unidentified material. They found that the lint cleaner removed larger trash particles more efficiently. Most of the waste both before and after the lint cleaner was leaf, followed by non-cotton, stem, seed, and boll material, and removal by the lint cleaner appeared to be highest for seed and lowest for leaf material. The results of the experiment by Morey et al. (1976) were limited in how they apply to the results of the current beltwide lint cleaning survey. They evaluated one cotton variety from one field and did not analyze approximately 70% of the visible waste as it was too small to characterize or was entangled in an uncharacterized "lint ball."

Morey (1979) analyzed trash in 71 commercial bales from 1974 to 1977. Bales were classed by the USDA Agricultural Marketing Service and grouped by grade, with the best grade (GM or Good Middling) averaging 12.9 mg/g lint and the worst grade (GO or Good Ordinary) averaging 57.4 mg/g lint for visible waste determined by Shirley Analyzer. When trash was manually removed from lint and categorized by weight, the majority of the trash was leaf (ranging from 0.5 to 20.2 mg/g lint among grades) and seed (ranging from 4.6 to 17.1 mg/g lint among grades), followed by bark (0.2 to

8.4 mg/g lint), stem (0.1 to 5.8 mg/g lint), carpal (boll) wall (0 to 2.9 mg/g lint), and miscellaneous material (0.2 to 6.7 mg/g lint). These results differed from the results by Morey et al. (1976) in that seed (seed coat and embryo fragments) was much more prominent. In the previous study (Morey et al., 1976), perhaps a high concentration of seed coat remained entangled in the uncharacterized lint portion.

Most research on mass trash content of ginned lint has focused on the total trash content without quantifying the different fractions such as leaf, sticks, etc., but several sources have reported SCF weights along with total trash weights. Anthony et al. (1988) studied five Mid-south cultivars grown in 1983 and 1984 and showed that lint sampled before the lint cleaner had an SCF content of 28 mg/g lint and a total trash content of 47 mg/g lint. The results showed that the first lint cleaner reduced SCF content by 47% and total trash content by 48%, and SCF content equaled 60% of total trash content before and after the first lint cleaner and 66% after three lint cleaners. Anthony and Bridge (1986), after evaluating 20 Mid-south cotton cultivars grown in 1985, found that after two lint cleaners the SCF content ranged from 3.8 to 12.8 mg/g lint and trash content ranged from 10.7 to 28.4 mg/g lint. In a cultivar comparison study with 49 cultivars grown in two years, Anthony and Calhoun (1997) determined that the highest SCF content (after two lint cleaners) was 14 mg/g lint, but overall the SCF content averaged 6.4 mg/g lint and total trash content averaged 11.1 mg/g lint. Buser (2000) ginned Mid-south cotton on five different gin stands without lint cleaning and found that samples from the gin stand with the lowest SCF content (8 mg SCF/g lint) contained 34 mg/g lint total trash, and samples from the gin stand with the highest SCF content (18 mg/g lint) contained 42 mg/g lint total trash. Boykin (2006) analyzed cultivars grown in 2002 and 2003 and found that SCF content after lint cleaning ranged from 3.8 to 11.2 mg/g lint among 19 cultivars, and that Shirley Analyzer foreign matter ranged from 10.9 to 21.8 mg/g lint (Shirley Analyzer results not published). These studies showed that SCF typically account for nearly half of total trash content.

Anthony et al. (1988) showed that, before lint cleaning, SCF ranged from 14 to 37 mg/g lint among five Mid-south cultivars grown in 1983 and 1984. Mangialardi and Naarding (1988) surveyed 26 bales of cotton from the 1985 crop (13 from gins or compresses in California, six from Alabama, three from Texas, three from Georgia, and one from Louisiana) and found that SCF ranged from 2.7 to 7.3 mg/g lint. Mangialardi et al. (1990) studied six cultivars grown in 1986 at seven locations across the cotton belt and found that SCF ranged from 5 to 12 mg/g lint and averaged 7.4 mg/g lint without lint cleaning, but total trash content was not measured. These studies show that several factors influence SCF levels in lint, such as cultivar, environment, and various other production practices.

It is well documented that SCF is often a major portion of trash content, but there is little documentation in the literature concerning other trash fractions. Furthermore, there is no documentation of how each fraction of trash is changed by lint cleaning. The objective of this experiment was to categorize and quantify the type of trash found in lint sampled before and after lint cleaning at commercial gins and to determine cleaning efficiency for each category of trash.

METHODS

After seed cotton is dried and cleaned, it is mechanically fed into a gin stand to remove the lint from the seed. Lint then passes through one or two lint cleaners, and the clean lint is packaged in a cotton bale. Figure 1 is a schematic of typical machinery used in a commercial cotton gin to process upland cotton after drying and seed cotton cleaning. The type of gin shown uses saw-type gin stands and lint cleaners. In this test, samples were collected during two visits to nine commercial gins across the cotton belt. The first and second visits to a gin were differentiated by the letters “a” and “b,” respectively. For example, the first visit to commercial gin 1 was identified as gin-visit 1a. For each visit to each gin, five samples were collected simultaneously before and after lint cleaning. Lint cleaning varied among the commercial gins, which included either one or two saw-type lint cleaners. Commercial gins identified as 1, 4, 21, 22, 31, and 32 had one lint cleaner, and those identified as 3, 5, and 6 had two lint cleaners.

For each lint sample, two 5 g subsamples were analyzed at Cotton Incorporated in Cary, N.C., with an MDTA-3 (Micro Dust and Trash Analyzer 3, SDL Atlas, Stockport, U.K.) device to determine the contents of clean lint, trash, fiber fragment, and dust. This machine opens and cleans the lint and separates trash (greater than 500 μm), fiber fragments (less than 500 μm), and dust for weighing. The MDTA-3 trash portion was fractionated by hand to characterize the components. A lighted magnifying glass, forceps, and a standard No. 50 sieve (20.3 cm diameter with 300 μm nominal screen

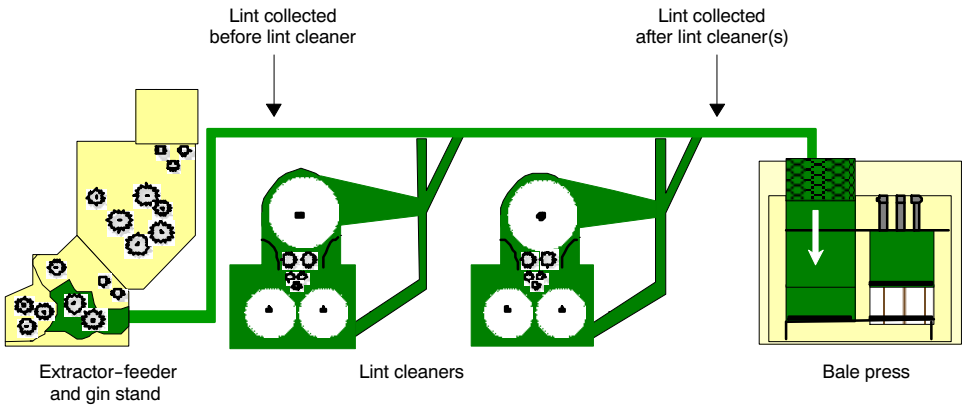

Figure 1. Typical ginning machinery after seed cotton cleaning and drying for upland cotton. One lint cleaner is often by-passed.

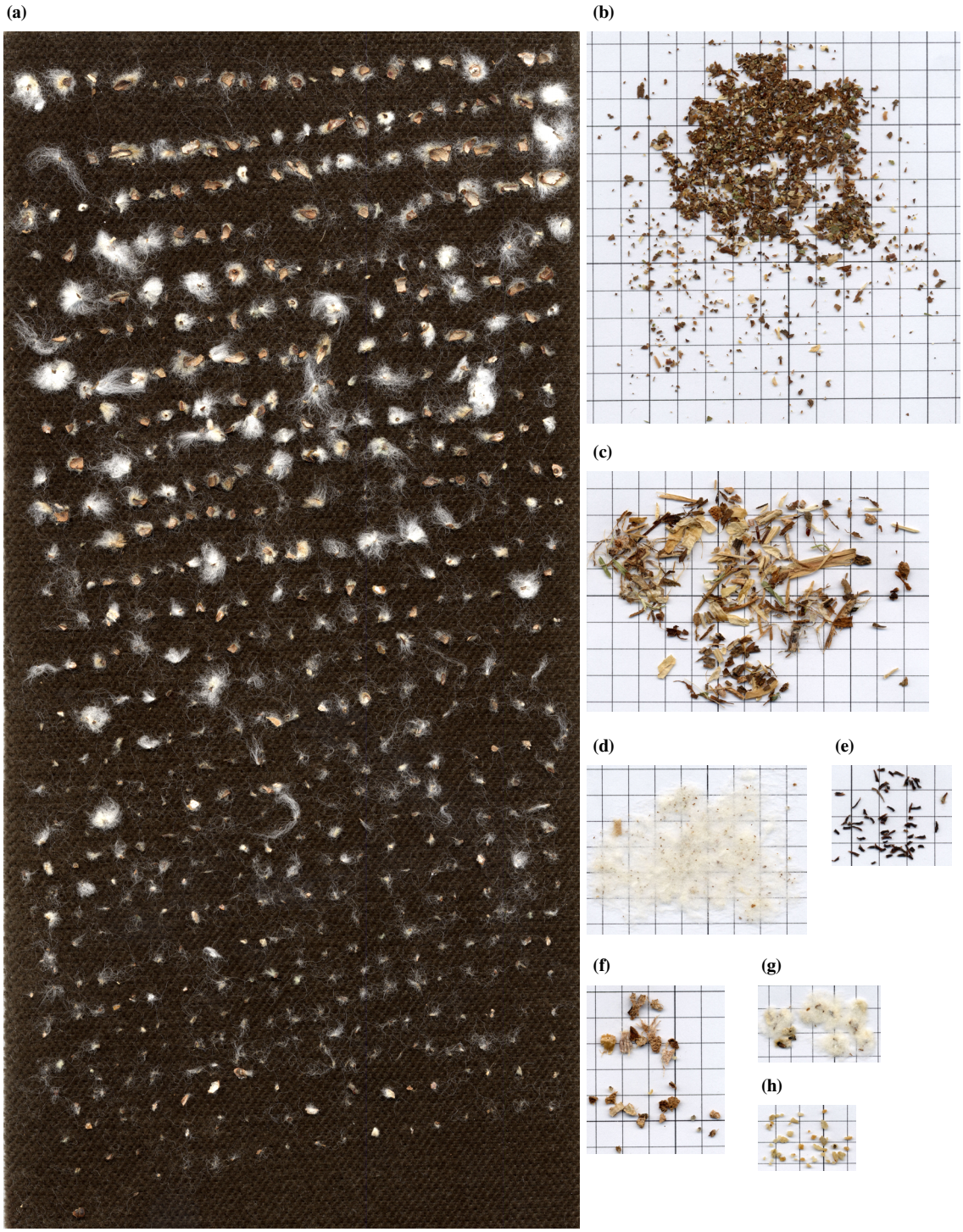

Figure 2. (a) Seed coat fragments, (b) leaf, (c) stick, (d) lint, (e) funiculi, (f) bark, (g) motes, and (h) other material manually separated from MDTA-3 trash fraction. This material was from a 10 g sample of lint collected before the lint cleaner on the first visit to gin 21. The grid scale was 0.5 cm.

openings) were used to sort the trash. Trash samples were placed in the sieve and manually shaken to help separate the components of the trash. Seed coat fragments (SCF), motes, lint, and funiculi were first removed from the trash sample since these were relatively easy to classify (fig. 2). The technician used the description of SCF, motes, and funiculi found in ASTM Method D2496 (ASTM, 1985). The remainder of the trash was then categorized as either stick, bark, other, or leaf (fig. 2). The description of each category was very simple and subjective: "stick" included elongated stick, stem, or fibrous woody material; "bark" looked like bark but did not fall into the stick category (different from bark as classified by the USDA Agricultural Marketing Service); and "other" did not fall into any other category and was clearly not leaf. "Leaf" was the remainder of the sample, which likely contained material other than leaf. A more rigorous classification with a microscope was not done so that the analysis could be completed in a reasonable time frame. Because of the very large number of very small particles in the "leaf" category, it would have been very difficult and time consuming to decide

whether each particle in the "leaf" category was actually leaf material. Much of the material that fell into the "leaf" category clearly resembled small pieces of leaf, but much of it was small, unrecognizable material that did not fit any of the other categories and was not easily distinguishable from leaf. The "other" material was typically seed meat fragments and weed seed.

Statistical analysis was performed with the MIXED procedure in SAS (2001) to include the following factors in the analysis: location (before lint cleaning and after lint cleaning), gin-visit (including individual visits to individual gins), and their interaction.

Results

MDTA-3 Trash Content

The clean lint portion (mg of clean lint per g of sample) increased as expected after lint cleaning (table 1). The trash content was reduced 57% after lint cleaning. Reductions in fiber fragment (not significant) and dust content also resulted from lint cleaning. Mechanical, varietal, environmental, and various other factors were confounded in the gin-visit factor, so differences among gins may not have been solely due to machinery, and the difference between two visits to a given gin may not have been solely due to time. However, it was important to note that significant differences in trash content associated with gin-visit meant that the study had a larger inference base for comparing lint before and after lint cleaning. The interaction between location and gin-visit was significant for trash content, which indicated that the effects of lint cleaning changed among visits to different gins, but the interaction was weak relative to the location factor, as indicated by the much larger F-values.

Manual Fractionation of MDTA-3 Trash

When the MDTA-3 trash portion was fractionated by hand, most was found to be leaf, SCF, and stick (table 2). The sum of these portions was 81% of the total trash content of lint both before and after lint cleaning. After lint cleaning, leaf, SCF, and stick were the major trash components, and bark, funiculi, mote, and other fractions were relatively small for each visit to each gin (fig. 3).

Table 1. Components of lint fractionated with the MDTA-3 trash analyzer.

Location		Clean Lint (mg/g lint)	Trash (mg/g lint)	Fiber Fragments (mg/g lint)	Dust (mg/g lint)
Before lint cleaning		950	45.0	3.19	1.36
After lint cleaning		978	19.3	2.14	0.92
Cleaning efficiency (%)[a]		3	-57	-33	-33
p-value	Gin-visit[b]	<0.0001	<0.0001	0.4360	<0.0001
	Location[c]	<0.0001	<0.0001	0.3028	<0.0001
	Gin-visit × location	<0.0001	<0.0001	0.5307	0.6454
F-value	Gin-visit[b]	21.81	39.92	1.03	6.91
	Location[c]	391.90	739.09	1.08	40.03
	Gin-visit × location	6.57	13.58	0.94	0.83

[a] Cleaning efficiency = (After - Before)/Before × 100.
[b] Each level of the gin-visit factor is one visit to one gin.
[c] Location is either before or after lint cleaning.

Table 2. Manual fractionation of trash removed from lint with the MDTA-3 trash analyzer.

	Percentage of Total Trash Weight							
Location	Leaf	SCF	Stick	Lint	Bark	Funiculi	Mote	Other
Before lint cleaning	33.1	32.2	16.1	5.7	3.9	2.4	2.2	1.0
After lint cleaning	31.0	34.4	15.6	7.3	2.3	2.5	1.9	0.7

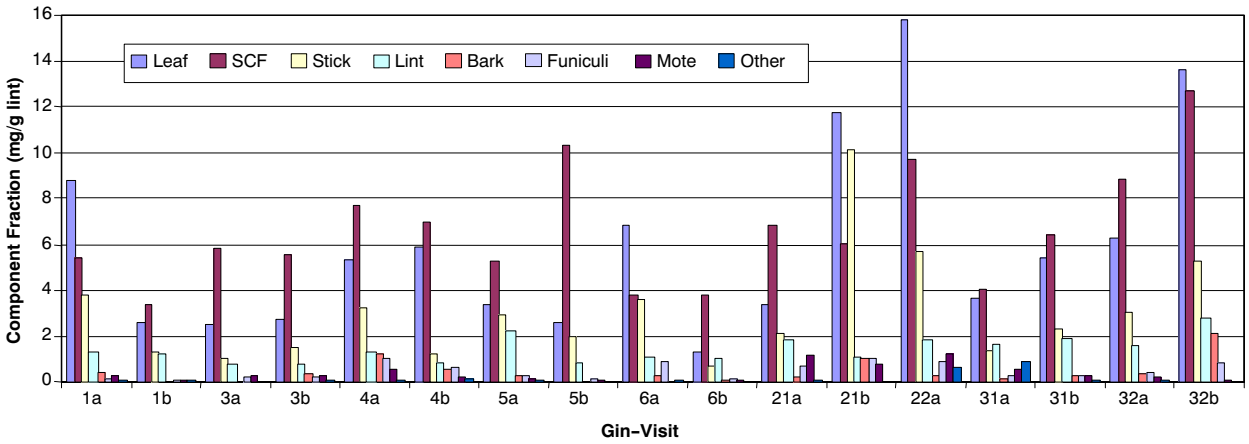

Figure 3. Manual fractionation of trash removed from lint after lint cleaning with the MDTA-3 trash analyzer. Gins 1, 4, 21, 22, 31, and 32 utilize one lint cleaner, and gins 3, 5, and 6 utilize two lint cleaners. The number and letter in the gin-visit code identifies the commercial gin and visit, respectively.

Table 3. Manual fractionation of trash removed from lint with the MDTA-3 trash analyzer.

Location		Least Square Means							
		Leaf (mg/g lint)	SCF (mg/g lint)	Stick (mg/g lint)	Lint (mg/g lint)	Bark (mg/g lint)	Funiculi (mg/g lint)	Mote (mg/g lint)	Other (mg/g lint)
Before lint cleaning		14.90	14.50	7.25	2.57	1.74	1.09	0.97	0.45
After lint cleaning		5.97	6.63	3.00	1.40	0.44	0.48	0.36	0.13
Cleaning efficiency (%)[a]		-59.92	-54.31	-58.59	-45.65	-74.52	-56.45	-62.60	-71.99
p-value	Gin-visit[b]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0015
	Location[c]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Gin-visit × location	<0.0001	<0.0001	<0.0001	0.0212	<0.0001	0.0003	0.0621	0.0023
F-value	Gin-visit[b]	56.51	26.11	36.92	8.11	10.50	17.54	8.93	2.84
	Location[c]	654.59	350.23	326.25	95.36	112.61	224.13	64.37	30.20
	Gin-visit × location	22.14	8.50	17.32	2.06	4.87	3.36	1.73	2.71

[a] Cleaning efficiency = (After - Before)/Before × 100.
[b] Each level of the gin-visit factor is one visit to one gin.
[c] Location is either before or after lint cleaning.

Removal of MDTA-3 Trash Fractions by Lint Cleaning

Lint cleaning significantly reduced each fraction of the MDTA-3 trash (table 3). Overall, the cleaning efficiency (percent difference seen before and after lint cleaning) did not vary much between trash fractions, but lint cleaning was slightly less effective at reducing SCF than leaf and stick. Higher percentages of the bark, mote, and "other" fractions were removed by lint cleaning, but these were small fractions of the total trash content. The highest cleaning efficiency was 75% for bark (again, this is different from bark as classified by the USDA Agricultural Marketing Service).

Effect of MDTA-3 Trash Fractions on Cleaning Efficiency

The efficiency of lint cleaning was the percent difference in trash content before and after lint cleaning. Total cleaning efficiency (table 1) and the cleaning efficiency of each fraction (table 3) have been discussed (table 3). When individual gin-visits were plotted, there appeared to be a slight increase in total cleaning efficiency with total trash content before the lint cleaner, but the trend was not significant ($p > 0.2$) and had a very low R^2 value (fig. 4). This result was also true when comparing leaf cleaning efficiency to leaf content before the lint cleaner (results not shown). For SCF, cleaning efficiency increased significantly ($p = 0.027$) when more SCF were present for removal (fig. 5). Stick cleaning efficiency did not

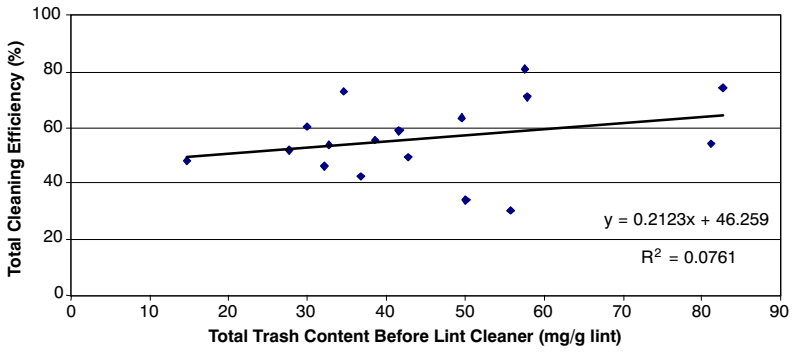

Figure 4. Total trash cleaning efficiency.

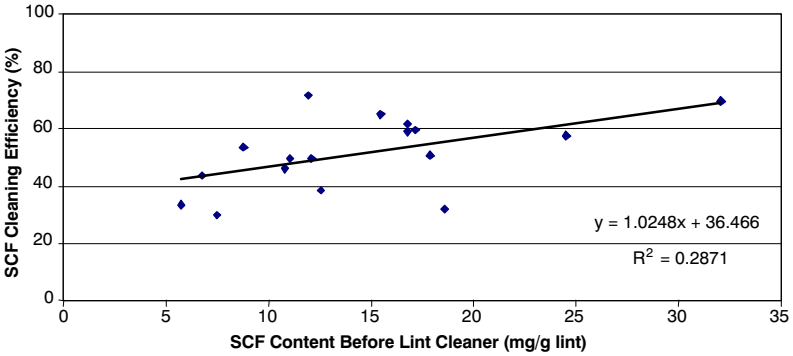

Figure 5. Seed coat fragment (SCF) cleaning efficiency.

change significantly ($p > 0.2$) with stick content before the lint cleaner, and this was also true for the removal of other trash fractions (results not shown). In addition, correlations between total cleaning efficiency and each trash fraction content before the lint cleaner were non-significant (results not shown, $p > 0.1$). These results indicated that, with the exception of SCF, total lint cleaning efficiency and cleaning efficiency of each fraction were not influenced by trash levels present before the lint cleaner. SCF were the most difficult to remove, but were removed more efficiently at higher levels of incidence.

Variation among Gins for MDTA-3 Trash Fractions and Cleaning Efficiency

Figure 6 shows the total, leaf, SCF, and stick cleaning efficiency for each gin-visit. For gin-visit 22a, leaf cleaning efficiency was lower than total cleaning efficiency, but for all other gin-visits it was about equal or higher. The SCF cleaning efficiency was low relative to total cleaning efficiency for gin-visits 3a, 3b, 5a, 5b, and 6b, but it was higher or about equal for all others. Stick cleaning efficiency was lower than the total for gin-visits 4a, 6a, 21b, 22a, and 32a, but it was higher or equal for all others. The total trash content before and after lint cleaning is illustrated in figure 7, and similar

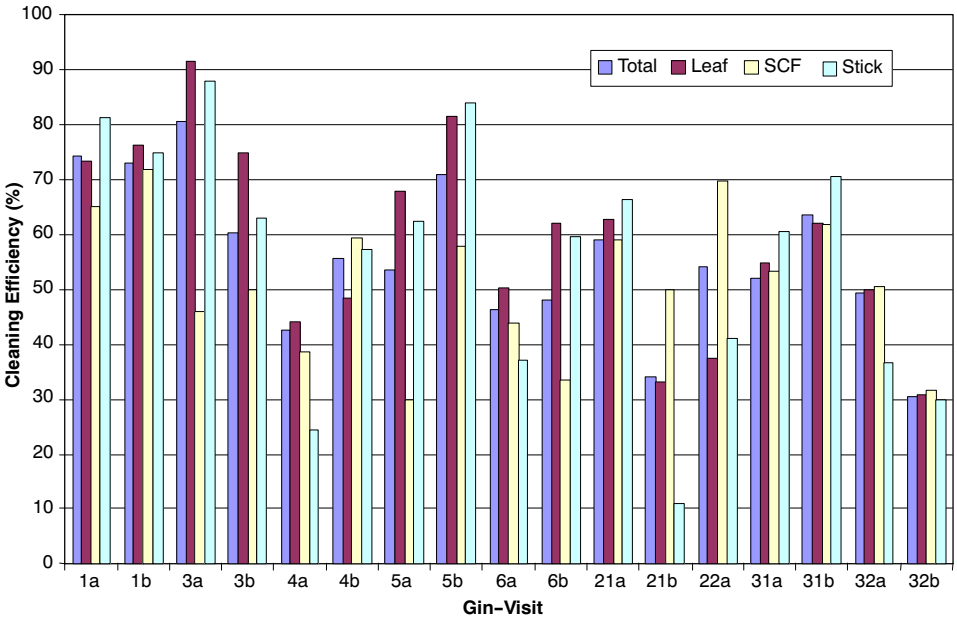

Figure 6. Total, leaf, SCF, and stick cleaning efficiency for each gin-visit. Gins 1, 4, 21, 22, 31, and 32 utilize one lint cleaner, and gins 3, 5, and 6 utilize two lint cleaners. The number and letter in the gin-visit code identifies the commercial gin and visit, respectively.

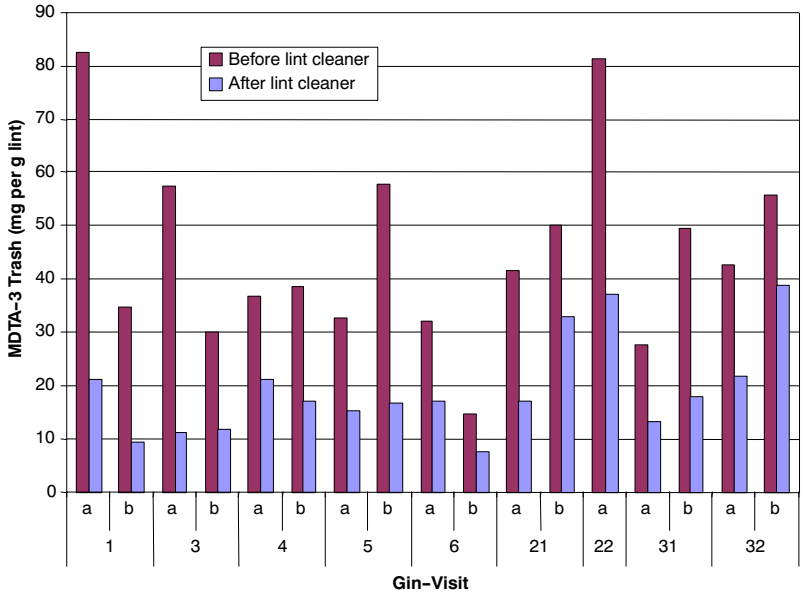

Figure 7. Total MDTA-3 trash content for each gin-visit. Gins 1, 4, 21, 22, 31, and 32 utilize one lint cleaner, and gins 3, 5, and 6 utilize two lint cleaners. The number and letter in the gin-visit code identifies the commercial gin and visit, respectively.

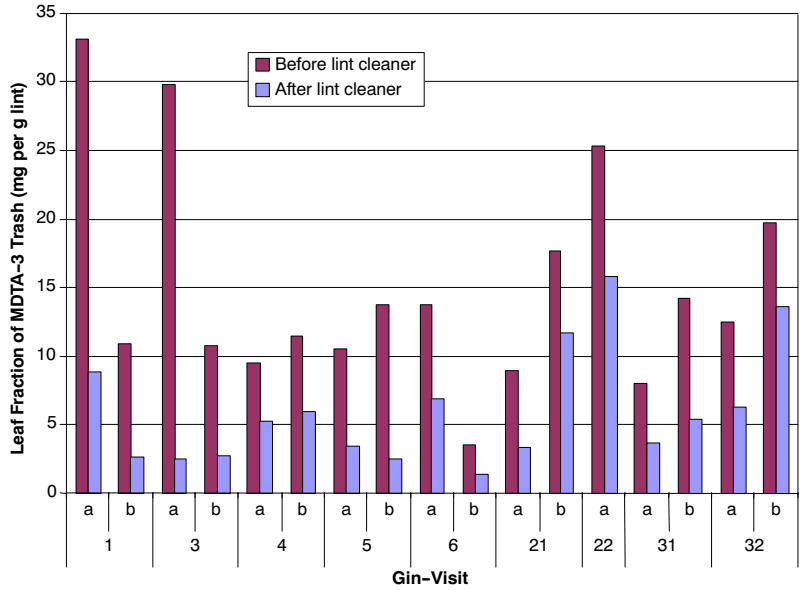

Figure 8. Leaf content for each gin-visit. Gins 1, 4, 21, 22, 31, and 32 utilize one lint cleaner, and gins 3, 5, and 6 utilize two lint cleaners. The number and letter in the gin-visit code identifies the commercial gin and visit, respectively.

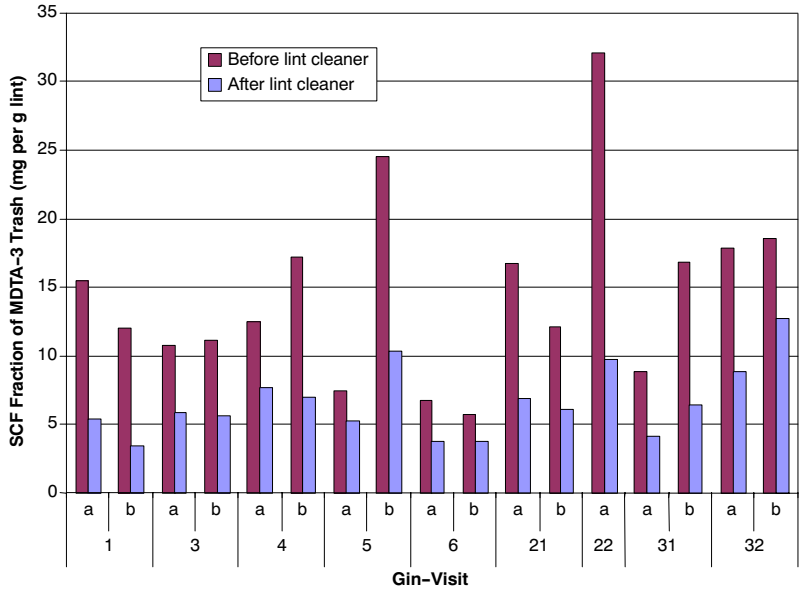

Figure 9. Seed coat fragment (SCF) content for each gin-visit. Gins 1, 4, 21, 22, 31, and 32 utilize one lint cleaner, and gins 3, 5, and 6 utilize two lint cleaners. The number and letter in the gin-visit code identifies the commercial gin and visit, respectively.

graphs show the fractional trash content for leaf (fig. 8), SCF (fig. 9), and stick (fig. 10). Variation in trash content and removal among gin-visits was most likely due to differences in the cotton being ginned for each gin-visit. Trash content is known to vary significantly among varieties and harvest conditions. These results show that SCF and sticks were sometimes more difficult to remove by the lint cleaner in comparison to other fractions, particularly leaf, which was relatively easy to remove in most cases.

Discussion and Conclusion

The major components of trash were leaf, SCF, and sticks, accounting for 81% of all trash both before and after the lint cleaner. Overall, the total lint cleaning efficiency was 57%. For the three major components, cleaning efficiency was greatest for leaf (60%), followed by sticks (59%) and SCF (54%). All types of trash were significantly reduced by lint cleaning, with bark reduced the most (75%) and SCF reduced the least. Recall that bark as defined in this study was different from bark defined by the USDA Agricultural Marketing Service. The lint cleaning efficiency for SCF was increased when high SCF levels were found before the lint cleaner, but this trend was not found for other fractions. When data were analyzed for individual visits to individual gins (there were 17 gin-visits), one had lower cleaning efficiency for leaf, five had lower cleaning efficiency for SCF, and five had lower cleaning efficiency for stick in comparison to the total cleaning efficiency. These results show that SCF and sticks were sometimes more difficult to remove by the lint cleaner in comparison to other fractions, particularly leaf, which was

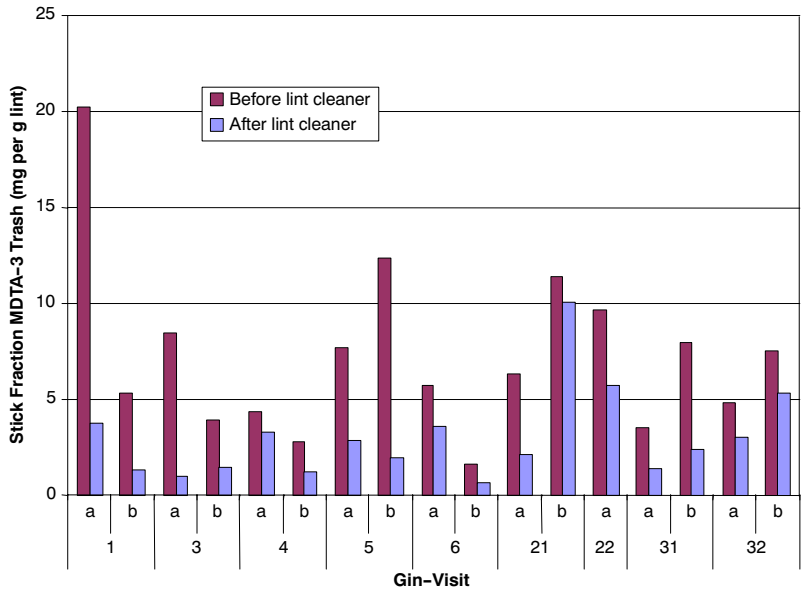

Figure 10. Stick content for each gin-visit. Gins 1, 4, 21, 22, 31, and 32 utilize one lint cleaner, and gins 3, 5, and 6 utilize two lint cleaners. The number and letter in the gin-visit code identifies the commercial gin and visit, respectively.

relatively easy to remove in most cases. The cleaning efficiency of SCF was probably lower due to attached fibers clinging to other fibers, and the cleaning efficiency of stick was probably lower due to the stick's typically elongated shape increasing their tendency to remain entangled in the lint. In order to improve the performance of lint cleaners, special focus is needed on stick and SCF removal. Future work is also needed to better characterize the contents of leaf, since it was a major component of lint trash.

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References

Anthony, W. S. 1990. Performance characteristics of cotton ginning machinery. *Trans. ASAE* 33(4): 1089-1098.

Anthony, W. S., and R. R. Bridge. 1986. Evaluation of the ginning characteristics of midsouth cultivars. ASAE Paper No. 865548. St. Joseph, Mich.: ASAE.

Anthony, W. S., and D. S. Calhoun. 1997. Processing cotton cultivars with conventional gin machinery. *Applied Eng. in Agric.* 13(5): 565-576.

Anthony, W. S., W. R. Meredith, Jr., J. R. Williford, and G. J. Mangialardi. 1988. Seed-coat fragments in ginned lint: The effect of varieties, harvesting, and ginning practices. *Textile Res. J.* 58(2): 111-116.

ASTM. 1985. D 2496: Standard test methods for seed coat fragments and funiculi in cotton fiber samples. West Conshohocken, Pa.: American Society for Testing and Materials.

ASTM. 2004. D 2812-95: Standard test method for non-lint content of cotton. West Conshohocken, Pa.: American Society for Testing and Materials.

Boykin, J. C. 2006. Genetic traits associated with seed coat fragments, motes, and neps. In *Proc. Beltwide Cotton Production Conf.*, 436-447. Memphis, Tenn.: National Cotton Council of America.

Buser, M.D. 2000. Update on the impact of modern gin stands on fiber quality. In *Proc. Beltwide Cotton Production Conf.*, 1585-1594. Memphis, Tenn.: Natl. Cotton Council of America.

Mangialardi, G. J., Jr., and W. J. Naarding. 1988. Seed-coat fragment levels in selected bales of U.S. cotton. In *Proc. Beltwide Cotton Production Conf.*, 166-167. Memphis, Tenn.: National Cotton Council of America.

Mangialardi, G. J., Jr., J. M. Halloin, and J. J. Herbert. 1990. Cottonseed characteristics associated with neps and seed-coat fragments. ASAE Paper No. 901504. St. Joseph, Mich.: ASAE.

Morey, P. R. 1979. Botanically what is raw cotton dust? *American Ind. Hygiene Assoc. J.* 40(8): 702-780.

Morey, P. R., R. M. Bethea, P. J. Wakelyn, I. W. Kirk, and M. T. Kopetzky. 1976. Botanical trash present in cotton before and after saw-type lint cleaning. *American Ind. Hygiene Assoc. J.* 37(6): 321-328.

SAS. 2001. SAS ver. 8.2. Cary, N.C.: SAS Institute, Inc.

Whitelock, D. P. M. D. Buser, C. B. Armijo, G. A. Holt, J. C. Boykin, T. D. Valco, D. S. Findley, and E. M, Barnes. 2007. Beltwide gin sampling: First season. In *Proc. Beltwide Cotton Conf.*, 1930-1935. Memphis, Tenn.: National Cotton Council of America.